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## MAGNETIC DAMPING FOR LABORATORY BALANCES

When a magnet is used to damp the oscillations of the beam of a laboratory balance there is obviously some danger that the magnet may introduce errors when magnetic materials are being weighed. Because of recent inquiries, it seemed desirable to obtain some definite data both on this danger and on the time of swing as affected by different degrees of damping. No attempt was made to study the effect of damping on the total time of making a weighing, largely because this depends so much on the personal equation and the kind of work that is being done. Moreover, this question is one that applies equally to any kind of damping.

The balance used had a capacity of 200 g and was reliable to 0.1 mg or perhaps somewhat better, and the damping device was one already on the market. The magnet was under the right-hand stirrup, about 13 cm above the scale pan.

In studying the possible effect of the magnet on articles weighed, most of the observations were made with either a nickel-steel 20 g weight or a round bar of steel  $5\frac{1}{2}$  cm long and weighing about 49 g. The presence of

the magnet did not introduce any error as great as 0.1 mg when either object was lying directly on either scale pan, nor when raised 6 cm above the left pan, nor when the bar was standing on end on the right-hand pan. However, when placed with its center 6 cm above the right pan (that is, about 7 cm below the magnet) the 20 g weight appeared nearly 2 mg too light, and when the bar was lying in a horizontal position at the same distance below the magnet, it appeared about 3 mg too light. With other magnets and other arrangements of the balance, these effects might be very different. These results seem of value, however, as giving at least the order of magnitude of effects that may be expected.

For loads below 100 g the balance was "dead-beat"; that is, the pointer would swing out to its final position and stop without further oscillations. For loads of 100 g or more the pointer would move very slightly once or twice after the first large deflection. The damping was slightly adjustable, but the balance could not be made dead beat at the larger loads, while, even at very small loads, the damping could not be made sufficient to obtain any conspicuous effects of excessive damping.

Damping which is less than dead beat has two conspicuous disadvantages. The first and most serious of these is that when the balance is nearly dead beat, the final motions are made so slowly that there is great danger of reading the index before the true equilibrium position has been reached. The other disadvantage is that these final motions require considerable time. For example, under one set of conditions, and for the same amount of deflection, the time required to come to rest was 35 seconds with damping that allowed two or three very slight motions after the first large deflection, but was only 7 seconds with critical damping; that is, with the minimum damping that would make the balance dead beat. With a load of 200 g in each pan, where only the former condition could be obtained with the apparatus available, the time was over one minute.

With any kind of dead-beat damping, it is always necessary to use some deflection from the position when arrested, in order to show that the balance is actually free to swing. This makes it especially important to note that the time which it takes the beam to come to rest depends very much on the size of the angle through which the beam is deflected. For example, for a certain set of conditions it took 20 seconds, to come to rest for a small deflection and 40 seconds for a large deflection.

A danger easily overlooked is the possible effect of a magnetic spot in the aluminum damping vane, whether incorporated in the material itself or whether attached to it. Errors from this latter cause were actually experienced in the test. To determine the possible magnitude of such effect a speck of steel weighing about 1 mg was attached to one edge of the plate about 2 cm above the magnet. This caused discrepancies up to about 0.3 mg, depending on the amount and direction of the deflections at which readings were taken and on the position of the magnet.

There does not seem to be much danger that magnetic particles will ordinarily become attached to the aluminum plate, yet it evidently is possible, and should be guarded against both by careful cleaning and by checking the action of the balance. If the magnet can be moved, the simplest method of checking is probably to determine whether moving the magnet in various directions has any effect on the equilibrium position. There should be no effect.

#### A MULTIPLE-RANGE POTENTIOMETER FOR MEASURING SMALL TEMPERATURE DIFFERENCE

An error occurs in this item on page 114 of Technical News Bulletin No. 188 (December, 1932). In the paragraph starting "In the bureau's work on the isolation," line 18, "0.04 mv" should read "0.04 microvolt."

#### MEASUREMENTS OF ULTRA-VIOLET SOLAR RADIATION ON SEA AND LAND

With the increasing use of ultra-violet radiation by physicians and the public for healing purposes, there is a demand for information regarding the ultra-violet solar intensity in various localities and under various atmospheric conditions. There is also a demand for simple instruments for measuring these intensities, and in turn there is a demand for methods of calibrating such instruments on a uniform basis.

In Research Paper No. 517, to be published in the January number of the Bureau of Standards Journal of Research, a description is given of the calibration of a selective photochemical, ultra-violet dosage intensity meter against a balanced thermocouple and filter radiometer, used as a standard. Data are given of the ultra-violet intensities of solar radiation in various localities at various elevations at several stations in Europe and upon the ocean.

The measurements show a high ultra-violet reflection from clean, fresh snow. The ultra-violet intensities over the ocean are not conspicuously higher than at a sea-level, dust-free station on land, at the same latitude and the same season of the year.

#### INTERFERENCE METHOD OF MEASURING THERMAL EXPANSION

Research Paper No. 515 on the interference method of measuring thermal expansion, which will be published in the January number of the Bureau of Standards Journal of Research, has been prepared in response to numerous inquiries for details of the method developed at the bureau and described in its Scientific Papers Nos. 393 and 485, and several articles in outside publications. It is intended as a manual for the use of those who wish to measure thermal expansions by the interferometric method. As such, a more complete description of the apparatus and methods developed can be included than would be in or-

der in a paper dealing primarily with the results of a particular set of measurements. The apparatus, method of making specimens, forms for taking data, and computation of data, each is the subject of a careful exposition. An appendix contains tables and special calculations.

#### THOMAS RECORDING GAS CALORIMETER

Methods of measuring heating values of gases were investigated in considerable detail at the bureau a number of years ago. The calorimeters used for the measurement of heating values at that time were all of the so-called manually operated type.

To obtain the heating value of a gas with a calorimeter of this type it is necessary to make a number of observations and to calculate the heating value from these observations.

In the last few years several calorimeters have been developed which are designed to operate continuously and to record heating values automatically, thus eliminating the necessity of making any calculations. An investigation of one of these calorimeters, the Thomas recording calorimeter, has just been completed at the bureau. The results obtained, which will be published as Research Paper No. 519 in the January number of the Bureau of Standards Journal of Research, indicate that the calorimeter can be relied on to give heating values with an accuracy of 1 per cent or better.

#### LITHOGRAPHIC PAPERS SENSITIVE TO ATMOSPHERIC HUMIDITY

Papers used in lithographic printing change in size rapidly with changes in moisture content of the surrounding air, according to results obtained in laboratory studies now in progress in the bureau's paper section. Need of more careful humidity control for pressroom air than was heretofore believed necessary is indicated if register difficulties arising from contraction and expansion of the paper are to be avoided.

Lithographic paper is so sensitive to relative humidity that the moisture content changes instantly as the moisture condition of surrounding air varies. All changes in the moisture content of the paper result in dimensional changes of great importance in printing requiring precisely registered impressions. In order to determine the importance of such changes, the bureau is studying 15 different papers

in a room where "manufactured weather" permits the control of relative humidity to 1 per cent and temperature to 1° F. Large sheets of the papers were exposed to successive relative humidities ranging from 28 to 72½ per cent, and the dimensions were carefully measured at each humidity to an accuracy of 0.001 inch by means of a special micrometer rule.

Dimension changes amounting to 0.005 inch or more in 50 inches, sufficient to cause serious difficulties in obtaining close register, were found to result from relative humidity changes of only 4 per cent, these being no greater than variations commonly tolerated in plants having controlled atmosphere. Furthermore, it was found that differences in dimensions resulting from bringing paper to balance with a fixed atmospheric humidity from different directions; that is, bringing the moisture content of a dry paper up or of a moist paper down to balance with the fixed condition, were important. Such differences in dimensions obtained by approaching a humidity from opposite directions were as great as differences caused by 10 per cent relative humidity variations.

The results are of significance not only to the lithographer but to the paper manufacturer and to the manufacturer of air-conditioning apparatus. Need for increased accuracy in control of atmosphere in printing plants appears to require the concerted attention of lithographers and air-conditioning equipment manufacturers in order to minimize waste resulting from distortion of the printing paper. The paper manufacturer can assist by furnishing paper with uniform moisture content nearly in balance with the standard humidity condition maintained in the printing plant.

#### SUMMARY OF INVESTIGATION OF ENGLISH CHINA CLAYS

As pointed out in previous numbers of the Technical News Bulletin (Nos. 113, 122, 127, 144, 152, 169, 176, and 186), the use of English china clays in domestic commercial whiteware bodies has made the possibility of substituting American clays for those from England the subject of considerable interest. A study of certain important properties of 15 English china clays has been made for the purpose of furnishing the manufacturer data which may be of assistance in such substitutions.

Chemical and petrographic analyses show all the clays to be much alike,

consisting mainly of kaolinite crystals or aggregates, with muscovite as the main impurity. In general, the softening point of the clays is about that of cone 34 (1,755° C.). The specific gravity in all cases increases slightly with increased heating to cone 14, after which there is a slight decrease. The volume shrinkage increases and the porosity decreases up to the same point. The best correlation was found to be between the base exchange capacities of the clays and their dry transverse strengths. In general, the English china clays studied group quite closely together in almost all of their properties, and probably the real significance of some of the data collected will not be evident until further study of the American china clays has been made.

#### REACTION BETWEEN DIATOMACEOUS SILICA AND HYDRATED LIME AT ELEVATED TEMPERATURES

A pozzolana is a substance which, though not necessarily cementitious by itself, possesses constituents that will combine with hydrated lime at ordinary temperatures in the presence of moisture to form stable insoluble compounds of cementitious value. Diatomaceous silica is such a pozzolanic substance. Investigations in England have shown that the pozzolanic activity of diatomaceous silica is increased by heating to about 630° C.

Accordingly, a mixture of domestic diatomaceous silica and hydrated lime (high calcium) was prepared which contained approximately 25 per cent  $\text{SiO}_2$  and 75 per cent  $\text{CaO}$ , figured on the nonvolatile basis. The powdered material was mixed with a little water, molded into bars, and heated in an electric resistance furnace. Free lime determinations were made on separate batches obtained by heating for one hour at different temperatures. Sufficient water was then added to each batch to react with the free  $\text{CaO}$  to convert it into  $\text{Ca(OH)}_2$ , and each batch was then aged for a week in a closed vessel to permit the  $\text{CaO}$  to become hydrated. This partially hydrated material was then ground in a ball mill so that approximately 95 per cent passed a No. 200 sieve. Briquets were then made which contained 1 part of this ground material to 3 parts of standard Ottawa sand and sufficient water to effect the desired consistency (one-half inch slump with a 2 by 4 inch cylinder). The briquets were stored for seven days in air saturated with water and maintained at

21° C. They were then removed from the molds and stored in water for 21 days before breaking.

The following table shows the results obtained:

Temperature of burning mixture	Tensile strength of briquets (28 days)
° C.	Lbs./in. <sup>2</sup>
600	95
700	115
800	135
1,000	210

It can thus be seen, that upon heating together diatomaceous silica and hydrated lime a product results which has hydraulic properties. If the material is heated at higher temperatures crystalline calcium silicates are formed.

#### CLAY IN CONCRETE

The effects of clay admixtures on the compressive strength, permeability, and durability of concrete have been investigated by this bureau with the cooperation of Hugh L. Cooper & Co. (Inc.), of New York, N. Y.

Concretes of three different proportions were tested. The first contained no clay, the proportions being fixed by the following conditions: (1) The bulk volume of the compacted sand was 15 per cent greater than the voids in the coarse aggregates, (2) the concrete contained five bags of cement per cubic yard, and (3) the consistency was such that a man walking in a large mass of concrete would sink at least 3 inches and not more than 8 inches. The other two concretes were mixed to the same consistency as the first (based on the penetration test) and were of the same proportions except that in one, clay was substituted for 10 per cent of the volume of the cement and in the other, clay was substituted for 7½ per cent of the volume of the sand. The proportions by weight of the three concretes were as follows:

Concrete	Proportions by weight				
	Cement	Water	Clay	Sand	Crushed rock
I.....	1	0.71	0.00	2.22	4.77
II.....	1	.81	.08	2.46	5.30
III.....	1	.74	.11	2.05	4.77

Three complete sets of specimens were made of each type of concrete, using three different brands of cements. In addition, three complete sets of those containing clay were made, each set with a different kind of clay, which made a total of 21 mixtures.

Specimens of each mixture were made for testing in compression at the ages of 7 and 28 days; 3, 6, and 9 months; and 1, 2, and 3 years. Absorption and permeability test specimens were prepared for testing first at age 3 months and then retesting at the ages of 6 and 9 months and 1, 2, and 3 years. All specimens were kept in damp storage at approximately 70° F. for 28 days, and thereafter some were stored outdoors and an equal number were subjected to freezing and thawing.

The replacement of 7½ per cent of the volume of the sand by an equal volume of clay increased the compressive strength in various percentages from 1 to 37. At nine months the permeability was decreased; later it was increased both actually and relative to that of the plain concrete without clay. It should be noted, however, that all of the concretes were practically impermeable in these tests.

The substitution of clay for 10 per cent of the volume of the cement, except for the first two or three months in the case of the ordinary Portland cement concrete, caused a decrease in strength of 0 to 10 per cent. The very slight permeability was not appreciably changed.

The replacement of 7½ per cent of the sand in one case and 10 per cent of the cement in the other by equal volumes of clay slightly increased the absorption for specimens stored outdoors, but did not appreciably change that of specimens frozen and thawed.

Four hundred cycles of freezing in air and thawing in water did no apparent injury to the concrete kept continually damp.

The concrete that was dried out after 40, 100, 150, and 200 cycles of freezing in air and thawing in water disintegrated within the range of 85 to 400 cycles.

The difference in absorption, permeability, and resistance to freezing and thawing between concretes containing and not containing clay were small.

A report of the investigation will be published as Research Paper No. 529 in the February issue of the Bureau of Standards Journal of Research.

#### PROPERTIES OF WHITE-METAL BEARING ALLOYS

The usual white-metal bearing alloys require tin or antimony, or both, as essential constituents. Both tin and antimony are so-called "strategic" metals and the potential military demands for them are considerable. These facts were responsible for the sponsoring by the War Department of recent studies at the bureau aimed toward the reduction or possible elimination of the amounts of tin and antimony needed for bearings.

One phase of this work was a study of the wear resistance and other mechanical properties of 11 white-metal bearing alloys. The alloys tested included 2 tin-base and 8 lead-base alloys, and 1 alloy of cadmium and zinc.

Each of the properties, with the exception of wear, was determined at several temperatures ranging from 20° to 200° C. (68° to 390° F.), since it is in reality the properties at the higher temperatures that play the major part in determining the success or failure of a bearing metal under service conditions. Resistance to wear was determined only at 20° C. No one of the alloys considered was found to excel in all of the mechanical properties studied. Thus, the tin-base alloys showed higher resistance to wear and in most cases had higher Izod impact values at each temperature of test than did the lead-base alloys. In most cases, however, the tin-base alloys showed lower resistance to pounding than the lead-base and cadmium-zinc alloys. The hardness numbers and compressive properties of the tin-base alloys were found to be lower than those for the cadmium-zinc alloy and the lead alloys hardened (1) by additions of calcium and barium and (2) by additions of calcium, sodium, potassium, and lithium. The mechanical properties of the lead-antimony-tin alloys, in most cases, were higher as the tin content was increased.

Crank-shaft bearings of four compositions were prepared for service tests in U. S. Army class B trucks. These compositions consisted of two tin-base and two lead-base alloys. The results of these tests indicated that the tin-base alloys were superior in their wear resistance to the lead-base alloys. These results were consistent with those obtained on wear in the laboratory tests.

A complete report of this investigation will be published as Research Paper No. 512 in the Bureau of Standards Journal of Research for January, 1933.

#### EFFECT OF LATHE-CUTTING CONDITIONS ON HARDNESS OF CARBON AND ALLOY STEELS

Previous work at the bureau on machinability of steels has been primarily to study the relations of composition and heat treatment of the cutting tools and steels cut, to lathe-tool life. Little attention has been given to the effects of cutting conditions, such as changes in the speed, feed, or depth of cut, on the properties of the steel cut. Obviously, this is a matter of primary importance in selecting machining conditions because of the very high cutting speeds made available by the introduction of the superhard cutting tool materials.

The bureau has recently completed an investigation of the effects of lathe-cutting conditions on certain properties of machined plain carbon and alloy steels. Comparisons were made of the work hardening resulting from changes in size, form, and composition of tools; speed, feed, and depth of cut; composition and heat treatment of the steel cut. Observations were also made of the influence of the cutting conditions on aging, corrosion resistance, chip hardness, and structure near the machined surface of some of the steels cut, and the effect of annealing temperatures (100° to 720° C.) on steels work hardened in the lathe tests. A detailed report of this work was presented before the American Society of Mechanical Engineers at the annual meeting in New York, December 5 to 10, 1932.

Preliminary tests, including a hardness survey with the Brinell, Shore, Rockwell, and Vickers instruments, showed that the Vickers instrument using a 10 kg load and diamond pyramid, was the best available method for exploring the extent of the work hardening produced by the action of the cutting tools.

It was found that the cutting speed had no appreciable influence on the amount of work hardening, but that, with a given area of cut, this was affected equally by changes in feed or depth.

The work hardening depends not only on the conditions of cutting, such as tool size and area of cut, but also on the composition and heat treatment of the steels. Tests made on annealed plain carbon steels ranging

from about 0.12 to 1.10 per cent carbon, showed that the steel of lowest carbon content gave the greatest increase in surface hardness under the conditions of the experiments. The work hardening at the surface decreased rapidly with increasing carbon contents of the steels up to about 0.4 per cent carbon, and thereafter less rapidly with further increase in carbon. The depth to which the carbon steels work hardened appeared to decrease with increase in the carbon contents. This difference in the susceptibility to work hardening of the annealed steels could not be attributed to the nitrogen contents of the steels.

Austenitic stainless steel containing 18 per cent chromium and 8 per cent nickel had a high capacity to work harden at the surface of the cut, even with shallow cuts; but with heavy cuts, the change in amount of work hardening was not so great. The amount of work hardening of this steel with shallow cuts was decreased by using tools ground with steep back slope. Work hardening this steel in the lathe tests to show an increase in surface hardness varying from about 40 to 100 per cent had no influence on the resistance of the steel to hot nitric acid attack.

The austenitic "free machining" "18-8" stainless steel had no marked increase in surface hardness with shallow cuts, but with increasing areas of cut there was a continuous increase in the work hardening produced.

The hardness of the cold-worked plain carbon and 3½ per cent nickel steels was, in general, increased by annealing within the range of 100° to 400° C; with further increase in annealing temperature the hardness decreased. The hardness resulting from cold working in lathe cutting was removed on heating to 720° C.

#### STRENGTH OF STEEL COLUMNS INCASED IN BRICKWORK

The columns in buildings with steel frames are usually designed to carry the entire weight of the building above them, no allowance being made for the added strength which incasement, such as in brickwork, may give them. It has been questioned whether any strength is indeed added by the incasement. Any increase in strength may be caused by partial transfer of load from the steel to the incasement by the bond between them and incasement of long columns might act as a continuous lateral restraint sufficient

to prevent lateral bending and cause the columns to fail in the same manner as short columns at much higher loads.

Practically no tests have heretofore been made to determine just what effect incasement does have on column strength although obviously a very important subject both from the standpoint of safety and of economy.

The bureau has recently made a preliminary study of this problem by testing six steel columns incased in brick walls. The columns were 23 feet long, and around them were built brick walls 14 inches thick, 6 feet long, and nearly the full column height. Three similar steel columns which had no incasement were also tested. The bare columns failed by bending at the mid-length, but the brick walls prevented bending of the incased columns, so that failure in these did not occur until the load was great enough to cause failure of the unincased length at the end. Measurements made during the tests showed that the steel in the incased portion of the columns was stressed, on the average, less than one-fifth as much as was the steel in the bare columns for the same load. There was practically no lateral deflection of the incased columns during the test. The results of these tests, showing that incasement of steel columns in brickwork strengthens the columns, may lead to considerable economy without sacrifice of safety in steel-frame building construction. These tests, however, represent only one set of conditions in the general problem of the effect of masonry incasement on the strength of steel columns. A comprehensive series of tests, in which all the other conditions that enter this complicated problem are investigated, would probably pay for itself many times in the savings effected. The results of this first series of tests are reported in Research Paper No. 520, which will be published in the January number of the Bureau of Standards Journal of Research.

#### ELIMINATION OF NIGHT EFFECTS IN RADIO RANGE BEACON RECEPTION

Research Paper No. 513, in the January number of the Bureau of Standards Journal of Research, describes a new antenna system for radio range beacon stations used in the guiding of airplanes. This antenna eliminates the troublesome night effects hitherto experienced. Considerable data, comprising ground and flight measurements, are given on radio range bea-

cons using the present loop transmitting antennas, which show the severity of the night effects. These take the form of rapid and irregular variation of the indicated beacon courses, so that an airplane following the true course will receive, in varying amounts, off-course indications to the right, off-course indications to the left, and on-course indications. The data given indicate the dependence of the night effects upon the season of the year, time of day, nature of the terrain over which the radio wave is transmitted, location of the transmitting and receiving points, distance of the receiving location from the transmitting station, and form of the receiving antenna. Over mountainous terrain the night effects are often so severe that the useful distance range of the beacon course is limited to 30 miles or less. The new antenna system, which is free from night effects, produces beacon courses which are satisfactory throughout the required distance range (about 100 miles). Numerous experimental data are given comparing the performance of the new antenna with the conventional loop antenna under nearly identical conditions. The data include measurements taken on the ground and during flight.

The theory underlying the occurrence of night effects when using loop transmitting antennae is briefly outlined. The theoretical analysis shows that the night effects are produced by horizontally polarized electric field components in the sky wave radiated from the horizontal elements of the loop transmitting antennae. At a distant receiving point, the angle of elevation for any of the usual altitudes attained by aircraft is small, and only the vertically polarized ground wave is received during the daytime. At night, since the indirect wave is reflected down from the Kennelly-Heaviside layer, the horizontally polarized components present in the indirect wave are received. These horizontally polarized components produce a virtual rotation of the beacon space pattern, the direction and degree of rotation depending upon the relative magnitudes and phase of the horizontally and vertically polarized components in the received wave. The beacon courses rotate or swing in space as the beacon space pattern is rotated; the irregular variation of the indicated beacon courses being accounted for by an irregular variation in the ratio of horizontally polarized to vertically polarized electric field components in the received wave.

On the basis of this analysis, it might appear that the use of a vertical receiving antenna would eliminate the effect of the horizontally polarized electric field components in the sky wave. This does not hold, however, since upon reflection of the sky wave from the Kennelly-Heaviside layer, a rotation of the components of the sky wave takes place, so that the original horizontal component becomes vertical in part and can affect a vertical receiving antenna. It follows that the only solution is to eliminate the radiation of the horizontally polarized component at the transmitting end. This is accomplished by neutralizing the radiation from the horizontal elements of the directional transmitting antennas.

The "transmission-line antenna system," described in this paper, employs four vertical antennas placed on the corners of a square; two of the antennas on the diagonal corners working together to replace one of the loop antennas of the radio range beacon stations, while the other two replace the other loop antenna. The significant element of the system consists of the use of transmission lines for confining the radiation to the four vertical antennas. The principle upon which the antenna system is based has been the subject of considerable experimentation in England for some time. The arrangement employed by the bureau involves a number of important new features which permit the application of the system to the radio range beacon with practically complete elimination of night effects.

Details of the electrical performance of the transmission-line antenna system are given, including requirements for component parts of the system. A method is described for aligning the four courses of the radio range beacon with airway routes intersecting at arbitrary angles, without requiring the use of an auxiliary central open-type antenna (as is the case when using loop transmitting antennas).

#### MUFFLERS FOR AIRPLANE ENGINES

For the past four year the Aeronautics Branch of the Department of Commerce, through its research division at the bureau, has been conducting an investigation on the possibility of developing practical methods of reducing the noise in airplanes. The results of various phases of the work have been published. The latest work has dealt with mufflers for reducing the noise of the engine exhaust.

In response to an invitation for the public to cooperate in the study of mufflers, seven were received for test. To these were added three designed experimentally at the bureau. Measurements of the reduction in noise and the reduction in engine power resulting from the various mufflers were made at the engine testing laboratory in Arlington, Va.

A 180-horsepower, V-type, water cooled Hispano-Suiza engine was connected to a hydraulic dynamometer which served for measurement of the engine power. The propeller was purposely omitted so as to make the effect of the mufflers more easily measurable. A centrifugal blower driven by an electric motor provided a blast of air to simulate the slip stream. The air from the blower was directed over the mufflers and thus the mufflers received the cooling effect of the slip stream.

The sound-measuring equipment consisted of a calibrated condenser microphone, an attenuator box, an amplifier, and an a. c. voltmeter of the full-wave copper diode rectifier type. Five band pass filters, transmitting frequencies of 0 to 250, 250 to 500, 500 to 1,500, 1,500 to 3,000, and 3,000 infinity cycles, were used to study the distribution of sound energy with frequency. The effective attenuation of the filters outside their nominal range was about 35 decibels. The working range of the apparatus was from 30 to 10,000 cycles.

The load imposed by the hydraulic brake was adjusted to give a speed of approximately 1,400 r. p. m. with the engine throttle set in the wide-open position. Corrections were applied for air temperature and barometric pressure, and the engine power computed for exactly 1,400 r. p. m., assuming constant torque.

Sound measurements were made at six stations at different distances from the engine. The microphone was held in the hand about 4 feet above the ground and pointed toward the engine. Readings were taken without a filter and with each filter in turn. With the aid of the calibration data the sound intensity at each measuring station was computed from the voltmeter readings for that station.

The power output of the engine and the noise level were determined for the following basic reference conditions: (a) All manifolds removed and the exhaust gases escaping to the atmosphere directly from the exhaust ports of the engine, (b) the side manifold attached, (c) the side manifolds

coupled together by means of a Siamese connection, (d) the exhaust gases piped from the Siamese connection to an underground muffler.

The above conditions were used for determining the reduction in horsepower and noise that should be credited to the various mufflers. Thus, when one muffler was used it was attached to the Siamese fitting and the effect was noted by comparison of the results with the results for the Siamese condition; when two mufflers were used one was attached to each of the side manifolds and the results compared with the results for the side manifolds; when mufflers were attached directly to the exhaust ports with no manifolding the results were compared with the results for the open ports.

The results of the sound measurements were expressed in decibels above a reference intensity of  $10^{-14}$  watts per  $\text{cm}^2$  per second.

The results for the underground muffler, which eliminated practically all of the exhaust noise, show that the noise level from valve clatter and other mechanical sources is comparatively high for any station near the engine, namely, 70 to 90 decibels. The intensity of the engine noise in the different frequency bands is remarkably uniform, the variation from the mean value being about 5 decibels.

The noise level for the open port condition is about 98 decibels for stations near the engine and about 83 decibels for stations about 80 feet from the engine. The intensity of the original noise in the various frequency bands is fairly uniform, the variation from the mean value being about 10 decibels. Obviously the exhaust noise does not have a dominant frequency although the intensity is greater in the high frequencies and there is a noticeable minimum in the 250 to 500 cycle band.

The experiments with mufflers indicate that the noise level of the exhaust and engine in the absence of the propeller can be reduced to about 80 decibels near the engine and to about 65 decibels at a distance of about 80 feet. The use of mufflers means a reduction of about 1.5 per cent in engine power and a slight decrease in payload as compared to an engine with manifolding.

It is not profitable to use a muffler unless the propeller tip speeds are sufficiently low to make the noise of the propeller less than that due to the unmuffled engine.

#### EFFECT OF AILERON DISPLACEMENT ON WING CHARACTERISTICS

An investigation of the effect of aileron displacement on wing characteristics has been completed by this bureau in cooperation with the Aeronautics Branch of the Department of Commerce and the National Advisory Committee for Aeronautics. Using a model mounted in the wind tunnel, measurements were made with the ailerons displaced various amounts for inclinations in pitch of the model to the wind of  $0^\circ$ ,  $12^\circ$ ,  $20^\circ$ , and  $40^\circ$ .

It was found that when the ailerons were displaced in the conventional manner (equally and in opposite directions) the lift was reduced, the drag increased, and the center of pressure moved forward. When one aileron was displaced downward both the lift and drag were increased and the center of pressure remained in nearly the same position. When one aileron was displaced upward, the lift was decreased by an amount greater than in the case of the conventional arrangement, the drag was decreased for a large part if not all of the range of aileron displacements investigated, and the center of pressure was moved forward about the same amount as in the case of the conventional arrangement.

A comparison of the 1-aileron and 2-aileron methods of determining the characteristics of the conventional arrangement showed them to be in substantial agreement.

#### ROLLING, YAWING, AND HINGE MOMENTS PRODUCED BY RECTANGULAR AILERONS

The bureau, in cooperation with the Aeronautics Branch of the Department of Commerce and the National Advisory Committee for Aeronautics, has been engaged for some time in a study of the problem of airplane control. One of the questions arising in this connection is that of securing the correct moments for rolling and yawing maneuvers by means of the conventional type of ailerons, with which the majority of commercial airplanes now in use are fitted.

As a result of this work, empirical equations, based on wind-tunnel data, have been developed, which will enable the designer to compute the magnitude of the rolling, yawing, and hinge moments due to the simultaneous displacement of conventional ailerons on monoplanes using the Clark Y or USA 27 wing sections. The forms of the equations are such that either the mo-

ments due to the ailerons or the dimensions of the ailerons themselves may be computed readily for any displacement between  $4^\circ$  and  $44^\circ$  and for either  $0^\circ$  or  $12^\circ$  pitch. A comparison of the equations illustrates the important fact that when the pitch angle is increased from  $0^\circ$  to  $12^\circ$  the hinge moment remains substantially constant while the rolling moment is decreased about one-half and the yawing moment is approximately doubled. This means that the magnitude of the rolling moment imposed by the ailerons in maneuvers can not be judged by the "feel" of the control column.

### JET PROPULSION

In its broadest sense, jet propulsion is the name for that type of propulsion which is characteristic of prime movers designed to work in a fluid medium, such as air or water, or in empty space. In a fluid the jet may be composed of the medium itself set in motion by some mechanical device, such as a screw. In empty space the fluid must come from within the vehicle itself. At one extreme we find the air screw and water screw, and at the other the rocket. Usage has eliminated air and water screws from the class of jet propellers, and has restricted that term to propellers in which the jet issues from nozzles. In particular, the term jet propulsion refers to propulsion by means of high-speed jets of relatively small diameter forced from nozzles by high pressure. Jet propellers in this restricted sense have a low propulsive efficiency as compared to the screw, because of the smaller amount of fluid from which propulsion is derived. To offset this is the simplicity that results from creating the jet by means of fluid under pressure, rather than by means of a moving mechanical mechanism external to the vehicle.

Probably because of its simplicity the jet propeller has always been regarded as an attractive type of prime mover. Numerous attempts have been made to use it, and all have failed to become practically useful; at low propelling speeds, because of the inherently low efficiency of the jet as compared to the screw propeller, and at high speeds, where the screw propeller is not so keen a competitor, and in empty space, because travel is not yet possible under these conditions. In applying the jet to propulsion in air, some experimenters have attempted to augment the jet with air from the surroundings, thereby shifting it into

the class of larger jets (such as those given by the air screw) and giving it a corresponding increase in efficiency. Molet and others have attempted to use something like an injector, employing curved guide rings or Venturi tubes concentric with the jet. Maurice Roy proposed mounting nozzles on the tips of a screw propeller. R. H. Goddard has tried to use the jet to drive air screws until a high speed at a high altitude is reached, and then to remove the screws and allow the jet to work alone. None of these schemes has as yet become practical. Furthermore, the last two tend to destroy the original simplicity.

The problem of augmentation was attacked at the Bureau of Standards at the request and with the financial assistance of the National Advisory Committee for Aeronautics. The purpose of the work was to determine from tests with compressed air whether the jet could be made a competitor of the air screw, using simple augmenting devices. Models of airships were tested, in one case with the jet issuing straight backward from the tail, in another with the jet spreading radially as a sheet over the nose, and in a third case with the jet spreading radially into the surrounding air from the tail. The first was found to be as good as, but no better than, the free jet (that is, the presence of the model did not affect the thrust), and the other two far inferior. A large variety of guide rings and venturis, such as those tried by Molet, were tested. The best of the jets augmented in this way was only 10 per cent better than the free jet. Nozzles which had the appearance of hollow truncated cones with the jet in the form of a cylindrical shell issuing from the end of smaller circumference were tried as a modification of the guide ring and venturi scheme. The best result was a 7 per cent increase over the corresponding free-jet reaction. An interesting experiment was tried in which a jet in the form of a sheet was made to issue nearly normal to the chord from the trailing edge of an airfoil. In a wind the jet induced such motions in the passing air as resulted in large lifts. It was impossible to throw a component of this lift into the wind by setting the airfoil at a negative angle of attack.

It is concluded that to augment the jet sufficiently to make it practical is a difficult if not impossible task. Taking the present results as typical, it seems that the jet will probably never find use at low speeds unless such

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lighter, more concentrated, and cheaper fuels than those now in use become available as will enable the free jet, in spite of its low efficiency, to compete with the screw.

**NEW AND REVISED PUBLICATIONS  
ISSUED DURING DECEMBER, 1932**

**Journal of Research<sup>1</sup>**

Bureau of Standards Journal of Research, vol. 9, No. 6, December, 1932 (RP Nos. 501 to 511, inclusive). Price, 25 cents. Obtainable by subscription.

**Research Papers<sup>1</sup>**

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RP493. The variation with angle of emission of the radiation from metals bombarded by slow electrons; C. Boeckner. Price, 5 cents.

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**Commercial Standards<sup>1</sup>**

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**Commercial Standards Monthly<sup>1</sup>**

Commercial Standards Monthly, vol. 9, No. 6, December, 1932. Price, 10 cents. Obtainable by subscription.

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**OUTSIDE PUBLICATIONS<sup>2</sup>**

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<sup>2</sup> "Outside publications" are not for distribution or sale by the Government. Requests should be sent direct to publishers.



